Unmanned aerial vehicles (UAVs) – A bird's-eye view in agriculture

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Unmanned aerial vehicles (UAVs) – A bird's-eye view in agriculture

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- UAV technologies are becoming more affordable, increasing the feasibility of their use within smaller-scale agricultural ventures
- Currently, the major focus of UAVs in agriculture is within the arable sector, with functionality in field mapping and crop assessment to improve yields
- There is currently an increasing amount of research being performed on utilising UAVs for livestock management and other precision farming integrations which could benefit farmers in the future

What are UAVs?

The term unmanned aerial vehicles (UAVs) covers a range of different remotely or entirely autonomously piloted crafts which are often referred to as drones. UAV refers to both more traditional fixed-wing aircraft, and also single or multiple rotorcraft, such as quadcopters, hexacopters, and octocopters. When considering a UAV for a particular use, it is important to consider the requirements for each application as specialised UAV are likely more suited to specific roles. For example, fixed-wing crafts can carry heavier payloads and can usually fly further and for longer. Alternatively, rotary-winged crafts have higher manoeuvrability and can be flown directly against the wind more efficiently as opposed to fixed-wing craft. Whilst initially UAVs were heavily used and developed for scientific and military uses, they are becoming more widespread with roles in areas including: mapping, search and rescue, agriculture, cargo transport, photography/cinematography, and environmental management. There are even proposals to use them in emergency health treatment. UAVs' CO_2 emissions when used to transport cargo have been assessed and are suggested, given the correct infrastructure, to be lower than current transport methods. As of February 2020, rotary based drones can be purchased with inbuilt high-quality cameras from as little as £369, making them far more accessible to hobbyist flyers. Companies are also working to develop new UAV to circumvent weight limits associated with drone registration restrictions in the UK.

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UAV legislation and restrictions in the UK

Currently, UK legislation relating to UAV usage set out by the Civil Aviation Authority (CAA) falls into two categories: regulations regarding crafts less than 20kg, and those concerning crafts over the 20kg limitation. Operation of larger craft over the 20 kg weight limit, is subject to standard UK Aviation regulations and individuals planning to pilot them must obtain specific authorisations and permissions from the relevant authorities. For the lighter category (<20kg), the legislation is more specifically defined as they are less likely to cause airspace interference issues. Any craft weighing between 250g and 20 kg to be used recreationally, must be registered by an individual or an organisation (£9 annual cost); operators must pass an online test (and renew this every 3 years); and the craft must be labeled with the operator's assigned ID. Any failure to comply with these legislations can lead to a fine of £1,000.

The CAA states that any business use of UAVs, regardless of size, is considered commercial. As such, commercial costs would be incurred when employing UAVs within the farming industry in the UK. (This parallels legislation in the US where the Federal Aviation Administration (FAA) states that any type of agriculture UAV use must be considered commercial.) In the UK, in order to obtain a commercial piloting license, an individual or organisation needs to gain 'Permission for Commercial Operations' (PfCO). Standard permissions allowing for commercial operations require a detailed operations manual and 'National Qualified Entity' (NQE) training (provided by a CAA approved trainer) to have been undertaken and passed (~£1,000). A fee must also be paid to the CAA per operator to register as a commercial pilot (£247) which is to be renewed annually (£130). Applicants must also have a compliant insurance policy (average cost between £600 - £1,000 annually). This leads to an initial cost of up to £2,247 with an annual cost thereafter of up to £1,130. In some instances landowners, over whose land non-commercial operators may be flying, may also specifically request a PfCO; one example being The National Trust.

The standard legislations of flight either as a non-commercial operator or on standard permissions for commercial flying have the following restrictions; the aircraft cannot exceed 120 metres height above the ground, the aircraft must be more than 50 metres away from any person, vessel, vehicle or structure, and the aircraft must be more than 150 metres away from any congested area (standard commercial operators are not bound by this) or open-air assembly of more than 1000 people. As well as these restrictions, there are expectations that pilots must maintain a visual line of sight (VLOS) throughout operations. Thereby UAVs, regardless of integration of a first-person camera feed, must be able to be viewed via VLOS at all times. In instances where first-person "goggles" are utilised, the operator must be paired with an individual who acts as a spotter throughout the flight to maintain VLOS. Where commercial flying is concerned, there are instances where exemptions, such as flying beyond the visual line of sight (BVLOS), may be requested via non-standard permission and sufficient evidence of competency to perform these operations safely are requested. Additional costs are likely to be incurred on the application for these.

UAVs in Agriculture

Early uses of UAVs in the agricultural sector have included remote sensing of arable crops and farmland status in general, usually to facilitate direct on-farm management practices. Previously, large-scale analysis of agricultural land has been reliant on satellite imagery which, in comparison to UAV-based technologies, can be slow to manifest, or temporally low resolution (meaning that images may be several months old), provide lower resolution imagery (particularly due to being blocked by clouds) and be linked to much higher costs. When used in remote sensing, drones can be fitted with red-green-blue (RGB) imaging equipment as well as multispectral cameras and near infra-red (NIR) sensors to fly over fields and assess several factors. Assessments can include; normalised differential vegetation index (NDVI) which allows determination of nitrogen contents of crops, water management via soil moisture content analysis, soil erosion evaluations and early indications of crop diseases. Other applications for crop management outside of the UK (due to current legislation bans) include the ability to integrate sprayers onto UAVs for remote applications of pesticides, insecticides or herbicides. Examples of software for crop-related UAV mapping currently include Dronedeploy and Datamapper, both of which act as central apps to programme flight paths for accurate image collection and 2D and 3D mapping with inbuilt NDVI analysis. Both options also are linked to many accessory apps allowing utilisation of specific add-on technologies such as NIR. This enables functionalities such as assessing water pooling, integration of field maps and is even compatible with John Deere software for use in autonomous tractor controls or variable rate application mapping. Light detection and ranging (LiDAR) sensors are also available for UAVs and can add to the resolution of 3D mapping along with accurately assessing crop height and biomass. The advantage of utilising these technologies on farms, is the cost-effectiveness and ease with which the data can be gathered and analysed by farmers. Development of software that can output management actions in a straight forward manner, rather than purely numerical data being returned as is common, would add another level of convenience.

In the past, UK farmers tend to have required the assistance of specialist companies to make management plans based on raw data, adding additional costs as each freehold is relatively small compared to the potential scope of the company resources. The majority of companies offering UAV farm analytics to farmers are based in Australia and the United States where large scale arable enterprises make this kind of service feasible. Recently, however, there has been an increase in the availability of these services to UK agriculture. This was credited to have been initiated by the now-dissolved URSULA Agriculture Ltd based in Aberystwyth.

Other than crop-specific applications of UAVs, there has been consistent discussion, throughout multiple review articles on precision farming, relating to UAVs for proposed roles in livestock management. Whilst research in this area is in its infancy, several aspects are being assessed including; visual detection and identification of livestock (for counting and monitoring location), herding of livestock, treatment of livestock (spraying ectoparasites) and evaluating feeding.

With regards to counting, one company has utilised automatic object detection algorithms to produce an app (now available) which can take pre-programmed flight paths over fields and count sheep. UAV technologies such as multispectral lasers, used for evaluating and inspecting buildings, could be mounted to agricultural UAVs in the future to concurrently inspect farm infrastructure in addition to other farm activities. Research into animal behaviour response to UAVs may also offer the potential for a 'scarecrow' effect in protecting crops or even livestock from predators during vulnerable periods such as lambing or calving outdoors. With regards to outdoor lambing and calving, integration of thermal imaging onto drones could assist in overnight monitoring of livestock, reducing farm labour and increasing animal welfare. Thermal imagery, independently of UAVs, is currently in advanced testing for use in determining livestock illness and, could, therefore, be easily integrated into UAV systems in the future.

One area which could benefit livestock, as well as precision farming in general, with regards to UAVs, is their use as a "data mules". This involves carrying a recording device to collect data transmitted from other smart-connected devices across a farm during flight. Whilst technologies such as low-power wide-area networks (LPWAN) including LoRaWAN are currently of interest for use in agriculture, the topography of certain regions makes their coverage incomplete and UAVs could act to bridge these gaps in the signal, potentially offering higher speed transfers due to reduced distances and power needs. Trials have suggested this to be possible with UAVs reading data transmitted from cattle ear tags with little to no significant effects on animal welfare/behaviour. Research is also currently ongoing in utilising this principle of detecting animals with "tags", whereby the UAVs note their GPS location during communication to provide tracking of animals and monitoring of movement patterns of herds. This prospect allows tags to remain dormant until contacted by the drone using significantly less battery power than current alternative livestock GPS monitoring devices, thus they can be placed on livestock for months or years.

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Obstacles of UAV use in Agriculture

The main obstacles to overcome in the future use of UAV technologies in agriculture include: evidencing the cost-effectiveness of the direct outputs to farmers generated from information gathered from UAV systems, overcoming the current lack of tailoring of software to UK farming requirements and maximising potential whilst working within current legal limits. Data need to be integrated into whole-farm precision systems and translated into actionable outputs that don't require the assistance of specialists and their associated costs. Particularly where research into use in livestock management is concerned software systems are essentially not present and therefore need to be built from the ground up with farmers as a target operator if they wish to be successful. It is essential to get farmers involved with these technological developments at this early stage. This would mean they can influence the outputs to be most beneficial practically on farms.

Despite the increased availability and accessibility of UAVs, current regulations regarding their safe and legal flight make their application in many scenarios difficult. Where an agricultural application is concerned, this often involves covering large distances, with farm size averages for Wales at 49 hectares and England 86 hectares. Analysis of UAV flight patterns with the requirement for VLOS shows that over 3 times more flights are required compared to flying BVLOS. The agricultural sector will, in

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future, be in a position to present significant evidence to the CAA of the benefits of regularly flying BVLOS. Alternatively, they could petition to have specific agricultural-related mitigation to UAV legislation, in order to manage widely distributed mountain grazing herds or to assess upland vegetation, for example, dominant species such as *Molinia* and bracken which are subject to significant control strategies.

Summary

The use of UAVs in the agricultural industry is an ever-growing area of interest with current applications largely focused on arable management practices. Here in the UK, we are lagging behind many other countries in our adaptation of legislation surrounding UAVs, which could be limiting the prospects of many innovative agricultural enterprises. Whilst drone systems themselves are becoming ever more cost-effective and able to be integrated with an increasingly wide range of bolt-on technologies, the ease and specificity of the software accompanying these for normal agricultural use are somewhat limited. Particularly here in Wales due to the topography of many Welsh hill farms and widespread grazing, UAVs offer a potential solution to the evaluation and management of areas which are difficult to access and assess, as well as a potential reduction in negative compaction of land and other environmental detriments of utilising other vehicles.

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Note to editors:

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